Newsletter, autumn 1995: 31 pp.

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski, 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5: 272-289.

Kimmerer, W. J., 1997. Flow effects and density dependence in striped bass. Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary Newsletter, autumn 1997: 31 pp.

Lasker, R., 1984. The role of a stable ocean in larval fish survival and subsequent recruitment, in R. Lasker (Ed.), Marine fish larvae: morphology, ecology, and relation to fisheries. University of Washington Press, Seattle, WA. 131 pp.

Lechowicz, M. J., 1982. The sampling characteristics of electivity indices. Oecologia 52: 22-30.

Limburg, K. E., M. L. Pace, D. Fischer, and K. K. Arend, 1997. Consumption, selectivity, and use of zooplankton by larval striped bass and white perch in a seasonally pulsed estuary. Transactions of the American Fisheries Society 126: 607-621.

Merz, J. E. and C. D. Vanicek, 1996. Comparative feeding habits of juvenile chinook salmon, steelhead, and Sacramento squawfish in the lower American River, California. California Fish and Game 82: 149-159.

Obrebski, S., J. J. Orsi, and W. Kimmerer, 1992. Long-term trends in zooplankton distribution and abundance in the Sacramento-San Joaquin Estuary. Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary Technical Report 32: 42 pp.

Orsi, J. J., 1995. Radical changes in the estuary's zooplankton caused by introductions from ballast water. Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary Newsletter, summer 1995: 19 pp.

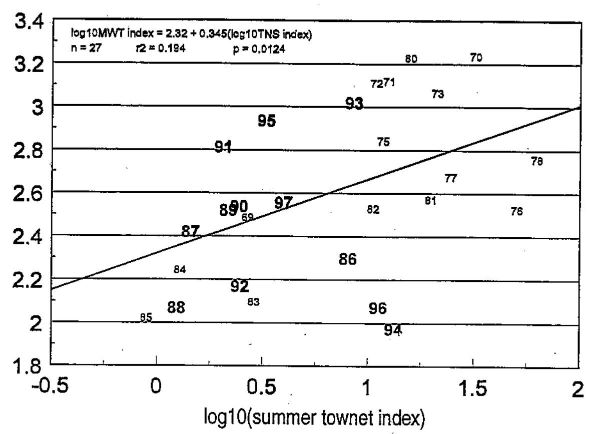

Figure 7
Relationship between the summer tow net index and fall midwater trawl index for delta smelt 1969-1997. Data points since the introductions of *Potamocorbula* and *Pseudodiaptomus* (1986-1997) are in bold type.

Going Surfing

Randall Brown, DWR

Effective February 1, 1998, Pat Coulston, IEP's Program Manager, will assume a new position with the Department of Fish and Game's Region III. Pat will be assigned to the region's Monterey office and probably will be found on a surf board during many of those evenings and weekends when the surf is up.

Pat has been Program Manager since 1994; prior to that he worked in the IEP's San Francisco Bay and fish facilities elements. Before coming to DFG in the mid-1980s, he worked in the Bay/Delta with a private consulting firm.

Pat's performance in all his IEP assignments has been characterized by vision, technical competence, dedication, enthusiasm, and an unfailing (well, almost unfailing) infectious cheerfulness. The IEP has evolved considerably over the past few years and much of this positive evolution is due to Pat's personal contribution. We will miss him but wish him and his family all the best in their move to the coast and in their new jobs. We hope he will be able to attend some of the annual Asilomar meetings to keep in touch with Bay/Delta people and programs.

San Joaquin Salmon

Tim Ford, Turlock Irrigation District

In response to my request, the IEP's Central Valley Salmon Team recognized the San Joaquin Basin Resource Monitoring and Coordination Group as a satellite team. (Satellite teams are included under the auspices of the Central Valley Salmon Team to increase coordination and information exchange among salmonid monitoring and research activities. Satellite teams may receive IEP funding but are not controlled by the IEP.) This group has met quarterly since December 1996 with the purpose of facilitating monitoring coordination and information exchange in the Stanislaus, Toulumne, and Merced rivers and the mainstem San Joaquin River between the mouth of the Merced and Mossdale.

I have been the coordinator of this group which has included representatives of DFG, DWR, SWRCB, USFWS, USBR, water districts, environmental groups and private consultants. Meetings have addressed salmon related activities as well as habitat monitoring, modeling and research. The group is co-sponsoring a February 4, 1998, monitoring/research/restoration workshop for the San Joaquin system.

Preliminary Results on the Age and Growth of Delta Smelt (*Hypomesus transpacificus*) from Different Areas of the Estuary Using Otoltith Microstructure Analysis

Lenny Grimaldo and Bonnie Ross, DWR and Dale Sweetnam, DFG

Introduction

For many estuarine fishes, recruitment is related to larval growth rates (Houde 1987). Even small changes in growth rates can translate into tenfold changes in annual abundance (Houde 1987; Rutherford, Houde, Nyman 1997). For delta smelt (*Hypomesus transpacificus*), Moyle *et al* (1992) hypothesized that the growth of delta smelt rearing in the more productive, shallow waters of Suisun Bay would be greater than delta smelt rearing in the less productive, deep channels of the Delta. Support for this hypothesis emerged in 1994 when Hanson Environmental found delta smelt collected from Suisun Bay were larger than delta smelt collected from the lower Sacramento River, suggesting that Suisun Bay might provide good habitat. Without data on individual age, however, it is unknown if the fish collected in Suisun Bay were larger because of increases in growth rate or because fish from Suisun Bay were older than fish collected from upstream locations.

The primary objective of this study was to investigate the age and growth of juvenile delta smelt using otolith microstructral analysis to determine if growth rates differ among locations in the Sacramento-San Joaquin Estuary. Secondarily, diet composition and zooplankton density were analyzed to investigate factors important to the growth and distribution of delta smelt.

Methods

Field Methods. Delta smelt were collected during Department of Fish and Game (DFG) 20mm Surveys 7 (July 10-13) and 8 (July 24-27) in 1996 (Figure 1). In these surveys, delta smelt were collected with a 1,600 micron plankton stretched mesh net measuring 5.1 meters long and mounted on a townet frame (a frame with skids and a mouth opening of 1.5 m^2). Zooplankton samples were collected by a 197 micron Clarke-Bumpus net mounted on top of the townet frame. All zooplankton and fish were preserved in 45% ethanol and taken to the DFG Bay-Delta office for identification. All fish collected were sorted and osmerids were identified to species.

Laboratory Processing. Delta smelt were placed in petri dishes with 2 ml ethanol and measured to the nearest 0.10mm SL. The saccular otoliths (largest pair) were removed using a scalpel. Otoliths removed from fish <20mm SL were mounted in cytoseal and remained unsectioned. Larger otoliths were mounted then sectioned with a low speed saw with a diamond wafering blade. Frontal sections were cut on a plane containing the core and rostrum. Sectioned

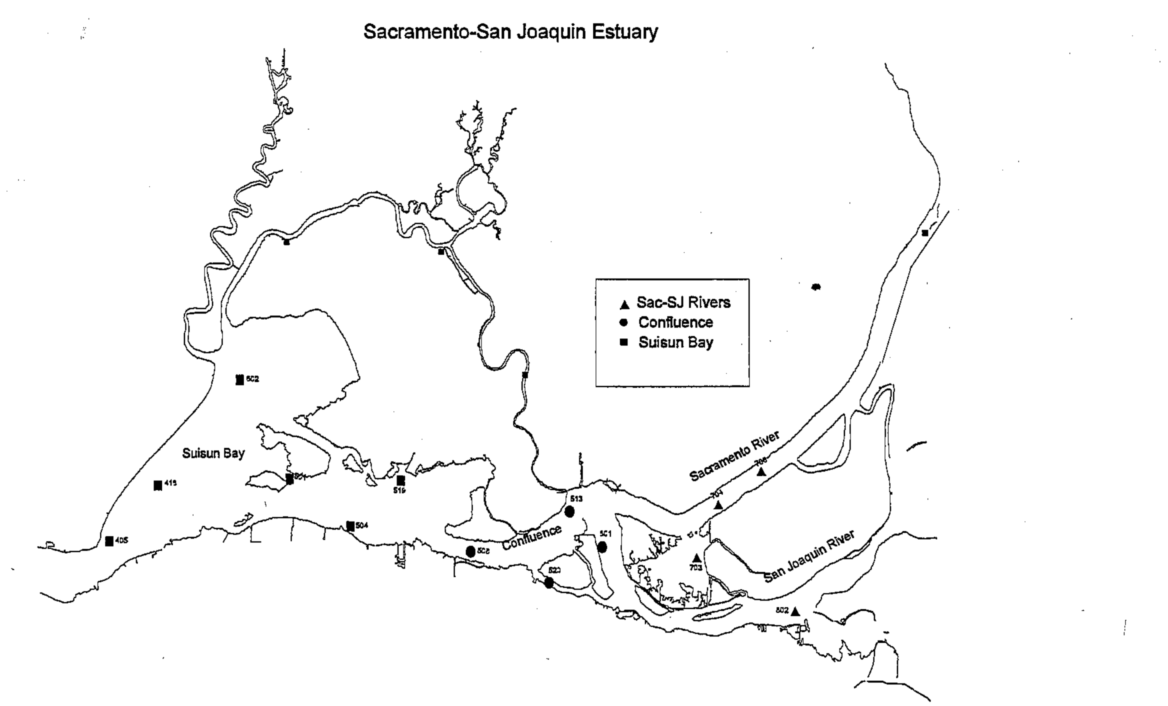

Figure 1
Stations where delta smelt were collected for otolith analysis in July 1996 (DFG 20mm survey).

Table 1. Delta Smelt by Growth Rate by Length Interval, July 1996
(Surveys 7 and 8)

Length Interval	Number	Growth Rate
<20mm SL	15	0.09
20-24mm SL	30	0.09
25-29mm SL	35	0.09
>30mm SL	60	0.18*

**Growth significantly (ANOCOVA, $F_{0.05;2,150,3.06}$, F=7.19 p<.05) improves for fish greater than 30mm SL.*

structures (~20 *um*) were initially sanded with 320 and 600 grit sandpaper, then polished on a felt pad coated with alumina powder.

Age estimation. Circulli within each otolith were counted independently by two people without knowledge of fish length or capture area. Individual rings were distinguished by changes from translucent to opaque bands (Nielsen and Johnson 1983). Discrepancies in age estimates were resolved after a second independent reading by each person.

Cultured Delta Smelt. Otoliths from known-age delta smelt cultured at the University of California Davis, 1994 were examined for verification of daily circulli formation and to familiarize ourselves with delta smelt otolith morphology. Cultured fish, 8 to 14 days post-hatch show that circulli are formed daily on delta smelt otoliths. Some older fish up to 50 days post-hatch were also examined, however the otolith microstructure was very irregular and changes between translucent and opaque bands were indistinguishable. These fish were grossly malnourished at the time of collection and it is thought this affected circulli formation. Nevertheless, based on results from the 8 to 14 day old fish we assumed that the number of circulli in an otolith represents the age of individuals over the size range of wild fish examined.

Age and Growth Analysis. The study area was divided into three areas for age and length comparisons: (1) lower Sacramento-San Joaquin rivers, (2) the confluence, and (3) Suisun Bay (Figure 1). Analysis of variance (ANOVA) was used to determine if length and age differed significantly for each area (Tukey multiple comparison test) and date (t-test). Assigned ages by circulli counts were plotted against individual lengths to determine growth rate. Regression analyses were used to identify significant relationships between age and length. Analysis of covariance (ANOCOVA) was used to compare growth rates by date and length.

Diet Analysis. The stomachs of fish analyzed for age were analyzed for prey composition and abundance by the DFG Bay-Delta office. Prey items were enumerated and identified to the lowest taxonomic order.

Results

A total of 150 delta smelt between 15 and 43mm SL were collected for otolith microstructural analysis during July 1996 from the lower Sacramento-San Joaquin rivers (n=31), the river confluence (n=61), and Suisun Bay (n=58). The mean length (28.22mm SL) of delta smelt collected in Survey 7 did not differ significantly (t-test, p = .25) from the mean length (27.54mm SL) of delta smelt collected in Survey 8, therefore the length data were pooled for analysis. Delta smelt captured in Suisun Bay were significantly larger (mean = 32.26mm SL) than smelt collected at the confluence (mean = 27.11mm SL; Tukey test, p <.05) and Sacramento-San Joaquin rivers (mean = 21.31mm SL; Tukey test, p <.05) by survey and month. Further, delta smelt captured at the confluence were also significantly larger (Tukey test, p <.05) than delta smelt collected from the lower Sacramento-San Joaquin rivers by survey and month.

Age and Growth. The there was no significant (t-test, p = .52) difference between mean age of delta smelt collected in Survey 7 (63 days) and Survey 8 (64 days). Delta smelt from Suisun Bay were significantly older (mean age = 76 days) than delta smelt from the confluence (mean age = 62 days; Tukey test, p <.05) and from the lower Sacramento-San Joaquin rivers (mean age = 40 days; Tukey test, p <.05). Further, delta smelt collected at the confluence were also significantly older (Tukey test, p <.05) than delta smelt collected in the lower Sacramento-San Joaquin rivers.

There was a highly significant (ANOVA, p <.0001) relationship between age and length (Figure 2). Similar significant relationships and slopes occur if the data are divided by individual Survey 7 (ANOVA, p <.0001) and Survey 8 (ANOVA, p <.0001). These strong relationships corroborate our assumption of daily ring formation in otoliths of smelt between 15 and 45mm SL.

A linear relationship between delta smelt length and age with fish coded by location suggests that delta smelt move downstream as they grow older (Figure 3). Growth rate comparisons were not made between each geographic region because residence time within each region is unknown. Plots of delta smelt growth rates for different length intervals shows that growth significantly (ANOCOVA, p <.05) improves in fish >30mm SL (Table 1).

Diet. Pseudodiaptomus forbesi was the most common and abundant (number per fish) prey type of delta smelt collected in this study (Figure 4). Delta smelt captured in Suisun Bay had the broadest diet composition. In addition, we found delta smelt feeding index (presence/absence of prey item) was lowest for fish in the 19-24mm SL (see Lott, this issue, for similar variations in feeding). *Eurytemora affinis* were absent from all delta smelt stomachs analyzed in July 1996.

Zooplankton. Results from concurrent Clarke-Bumpus tows show *Pseudodiaptomus forbesi* densities were highest at the confluence and lowest in Suisun Bay. No *Eurytemora affinis* were collected in July 1996.

Discussion

Delta smelt in Suisun Bay were larger than individuals collected from the confluence and lower Sacramento-San Joaquin rivers because they were older. These results are consistent with the well-documented downstream migration of rearing delta smelt (Moyle 1976; Moyle *et al* 1992). We did not make growth rate comparisons by area because residence time within each region was unknown. This does not imply that environmental factors in each region are not important for delta smelt growth and survival. Our results suggest that growth rate increases above 30mm SL, after potential larval feeding bottlenecks are surpassed as described by Lott and Nobriga (this issue).

A key question not answered by this study is why delta smelt move downstream from the lower Sacramento-

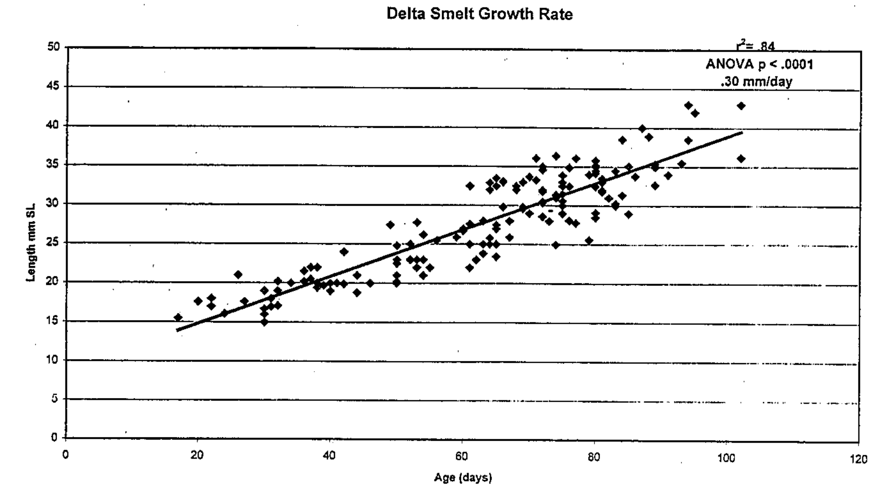

Figure 2
Growth rate plot for all delta smelt collected for otolith analysis July 1996 (n=150).

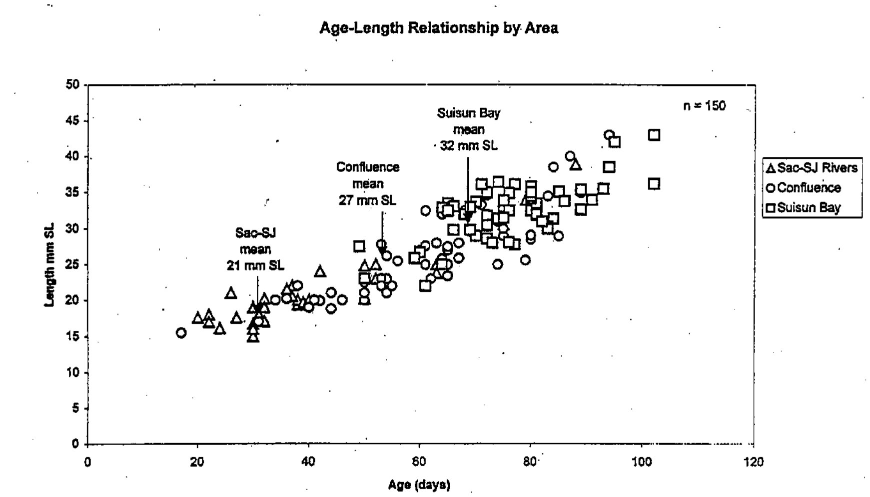

Figure 3
Delta smelt age and length by area for Surveys 7 and 8 together. Mean lengths from each are significantly different (ANOVA with Tukey p<.05).

San Joaquin rivers through the confluence into Suisun Bay as they grow older despite significant decreases in the density of a primary diet component. We observed that fish downstream of the confluence had a broader diet composition, so perhaps other prey types are a satisfactory replacement. Another possibility is that delta smelt continue to move downstream for physiological reasons. This species evolved in a brackish water environment, which historically had higher food levels, before the introduction of the Asian clam and other species of exotic zooplankton. Perhaps there is an osmotic advantage for residing in Suisun Bay, one which allows for lowered energy expenditure and historically, ample food resources.

Based on the results of this study, a more comprehensive study is warranted. Further, verification of daily increments for delta smelt >20mm SL is needed. The known-age delta smelt used in this study were from early culture efforts before feeding success was established in the laboratory and many were accidentally starved to death. This is probably why daily rings were not seen in fish >12mm SL. Recent success of delta smelt culture efforts (Lindberg *et al* 1997) would facilitate validation of daily rings. Field experiments using pen-raised delta smelt marked with tetracycline could also be worthwhile in verifying daily ring increments in otoliths. After confirmation of daily rings, a broader study using net-penned delta smelt raised in different regions of the estuary could determine if regional differences in growth rate exist.

Acknowledgments

Thanks to Leo Winternitz for initiating this study and the Interagency Ecological Program for funding it. We also thank Zachary Hymanson and Ted Sommer for editorial input and Erin Chappell, Lisa Lynch, and Sally Skelton from DFG Bay-Delta for laboratory assistance.

References

California Department of Water Resources and United States of Bureau of Reclamation. 1994. Effects of the Central Valley Project and the State Water Project on Delta smelt and Sacramento Splittail.

Houde, E.D. 1987. Fish Early Life Dynamics and Recruitment Variability. Transactions of the American Fisheries Society Symposium. 2:17-29.

Lindberg, J., R. Maeger, B. Bridges and S. Doroshov. Summer 1997. Interagency Ecological Program Newsletter. Volume 10, No. 3.

Moyle, P.B. 1976. Inland Fishes of California. University of California Press. Berkeley.

Moyle, P.B., B. Herbold, D.E. Stevens and L.W. Miller.1992. Life History and Status of Delta Smelt it the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 121:67-77.

Neilsen, L.A. and D.L. Johnson. 1983. Fisheries Techniques. Southern Printing Co. Blacksburg, Virginia

Rutherford, E.S., E.D. Houde, R.M. Nyman. 1997. Relationship of Larval-Stage Growth and Mortality of Recruitment of Striped Bass, *Morone saxatilis*, in Chesapeake Bay. Estuaries. Vol. 20, No. 1, p.174-198.

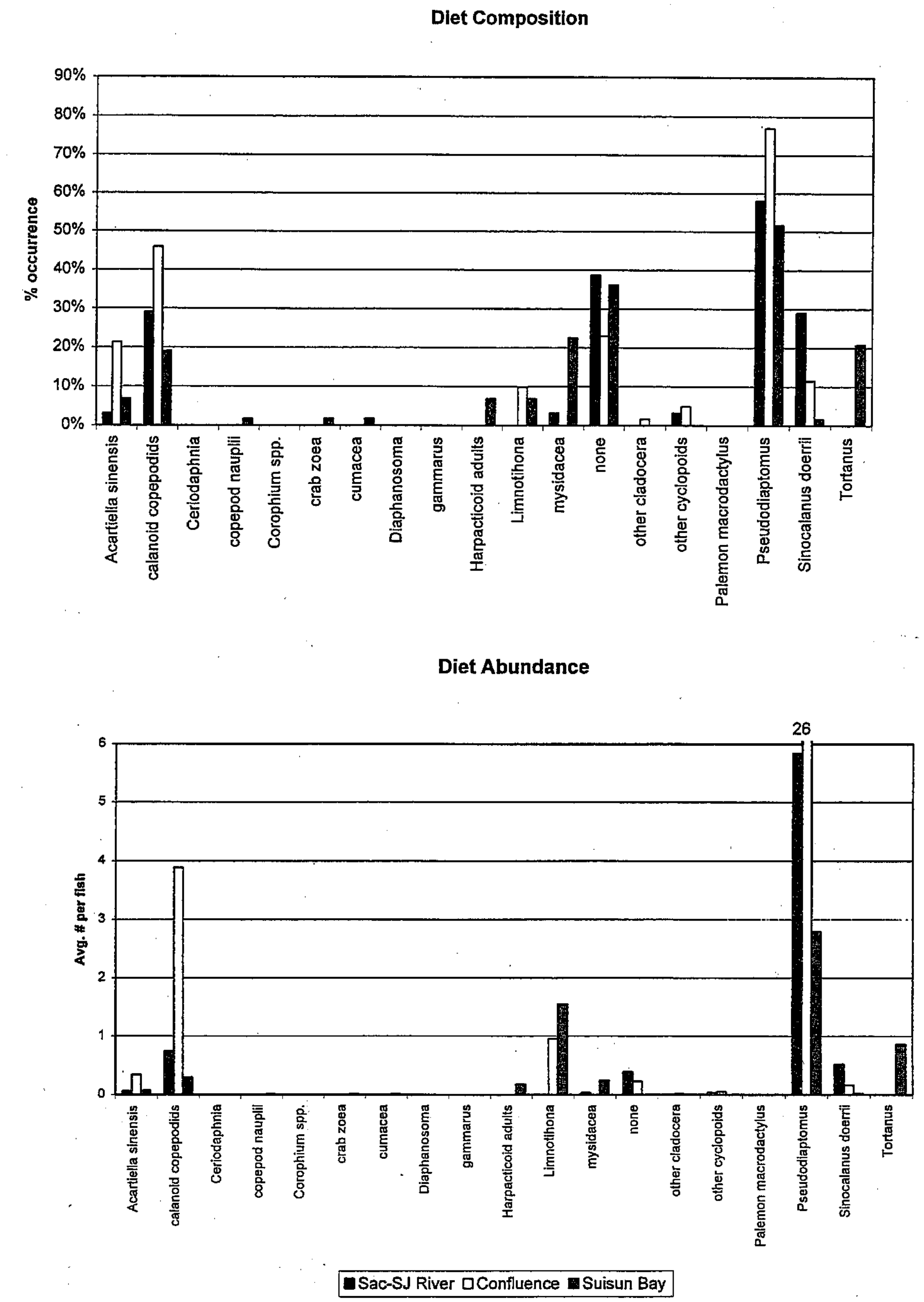

Figure 4
Delta smelt diet composition and abundance by area.

1997 Salmon Smolt Survival Studies in the South Delta

Pat Brandes and Mark Pierce, USFWS

Introduction

Salmon smolt survival studies in the Delta between 1985 and 1990 have shown that survival indices for coded wire tagged (CWT) smolts released at Dos Reis on the mainstem San Joaquin River survive at about twice the rate of smolts released into Upper Old River (Table 1, Figure 1). In response to these findings an attempt was made to test whether a temporary barrier in Upper Old River could improve survival for smolts migrating through the Delta.

A fully closed temporary barrier was installed in Upper Old River during spring 1992, 1994, and 1996. The study design in the first two years of evaluation was to make a series of releases at Mossdale in a four-week period: some releases were made prior to installation and additional releases were after the barrier was in place. Due to logistical considerations, the without barrier scenario was the first experimental condition tested.

In 1992, water temperatures increased after the barrier was installed such that the prebarrier releases survived at a higher rate than those released with the barrier. In 1994, all releases (both with and without the barrier) yielded indices that were too low to differentiate between groups. Neither year of testing was adequate to confirm the benefits of a barrier in Upper Old River.

In 1993 and 1995, San Joaquin River flows were too high for the temporary barrier in Upper Old River to be installed.

In 1996, the study design was changed to measure survival with a barrier in place for all releases and to make comparison with past years to determine if survival was higher than without a barrier. However, because the barrier was not installed until May 11 due to permitting delays and breached on May 16 because of flooding concerns, smolt survival with a barrier in place was inadequately measured in 1996.

In 1997, a study design similar to that planned for 1996 was used. Although the temporary barrier in Upper Old River was installed as scheduled (April 16 to May 16), it had two 48-inch culverts in it that allowed approximately 300 cfs of water from the San Joaquin River to move through the barrier into Upper Old River. The CWT experiment was then modified to assess the impacts of the culverts as well as to evaluate the benefits of the barrier on smolt survival through the Delta during spring 1997. This modification consisted of changing the smolts stock used for the Mossdale release (upstream of the barrier) from Merced River Fish Facility (MRFF) to Feather River Hatchery (FRH) stock. The concern was that losses through the culverts of Merced River smolts released at Mossdale would reduce returns back to the hatchery in future years.

Groups of CWT smolts were released at Mossdale, Dos Reis, and Jersey Point in the South Delta and recovered in sampling at Chipps Island as had been done in past years (Table 2, Figure 1). In 1997, additional inten-

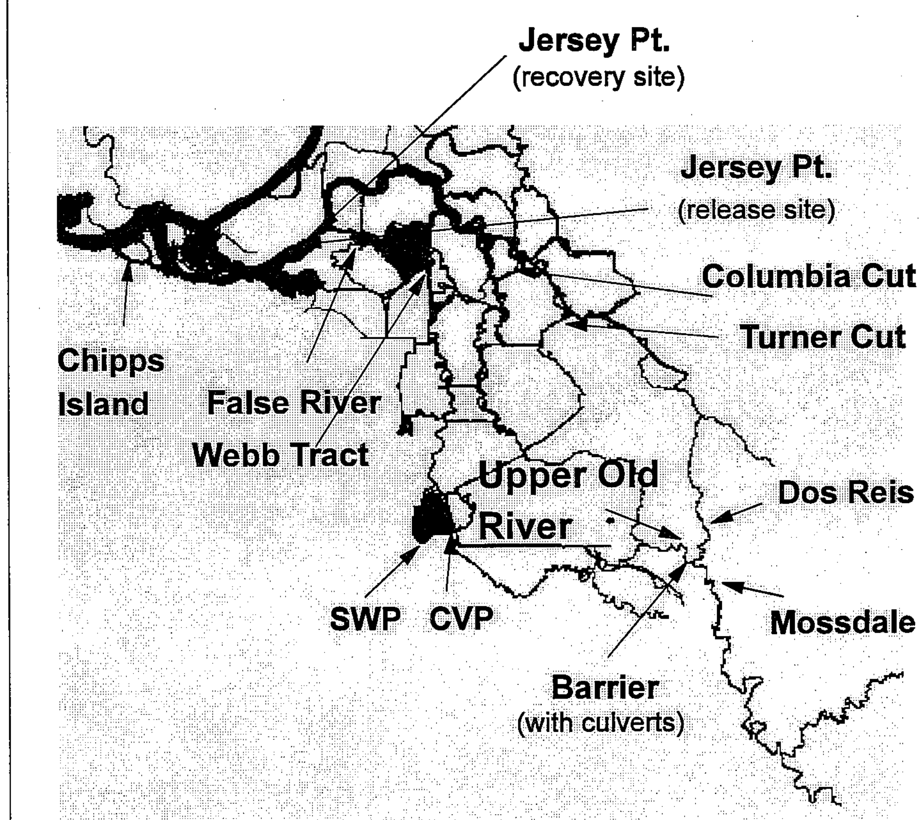

Figure 1
Map of release sites used in the South Delta in 1997 and recovery locations at Chipps Island, Jersey Point, the State Water Project (SWP), and Central Valley Project (CVP) fish salvage facilities and real-time monitoring stations.